A Proposal for Near-term Quantitative Support of Integrated Scenario Analysis for the 2009 California Water Plan Update

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1. Motivation

This proposal has been prepared in response to growing interest within both the California Department of Water Resources (DWR) and the water stakeholder community to use integrated scenario analysis as a foundation for the California Water Plan (CWP) Update process. This represents a departure from the supply gap analysis which was used in most previous Water Plans. Under supply gap analysis, planners projected demand into the future based on a single set of assumptions and then used this projection to calculate a supply gap based on a comparison to an assessment of currently available water supplies.

Supply gap analysis did not typically consider uncertainty in the underlying assumptions about demand growth or supply availability. It also did not explicitly weigh the advantages and disadvantages of various management response packages available to expand supply or moderate demand, such as increasing surface storage, reusing wastewater, conjunctively managing surface supplies and groundwater basins, increasing water use efficiency, and desalinating sea water. In response to these shortcomings, the CWP 2005 Update made a bold step away from supply gap analysis towards integrated scenario analysis by prominently featuring future demand uncertainty and multi-component water management response packages as key elements of the Plan.

In making this move, the CWP 2005 Update presented a useful graphical framework that lays out what DWR considered to be the key components of integrated scenario analysis. The Framework, presented in Figure 1, includes three levels. The top level corresponds to the input data and assumptions. These include assumptions about demand drivers —"How fast will California's population grow?"; geophysical parameters —"How will climate change impact the spatial and temporal patterns which characterize flow in California's rivers and streams?"; and water management objectives —"Will California relax or strengthen instream flow regimes designed to protect aquatic ecosystems?". There is uncertainty in the answers to all these questions and others which will be posed in an attempt to anticipate the future water management landscape in California. Integrated scenario analysis attempts to capture this uncertainty by defining scenarios based on the range of plausible demand drivers, geophysical states, and objectives. It is the top level of the framework where scenario definition begins.

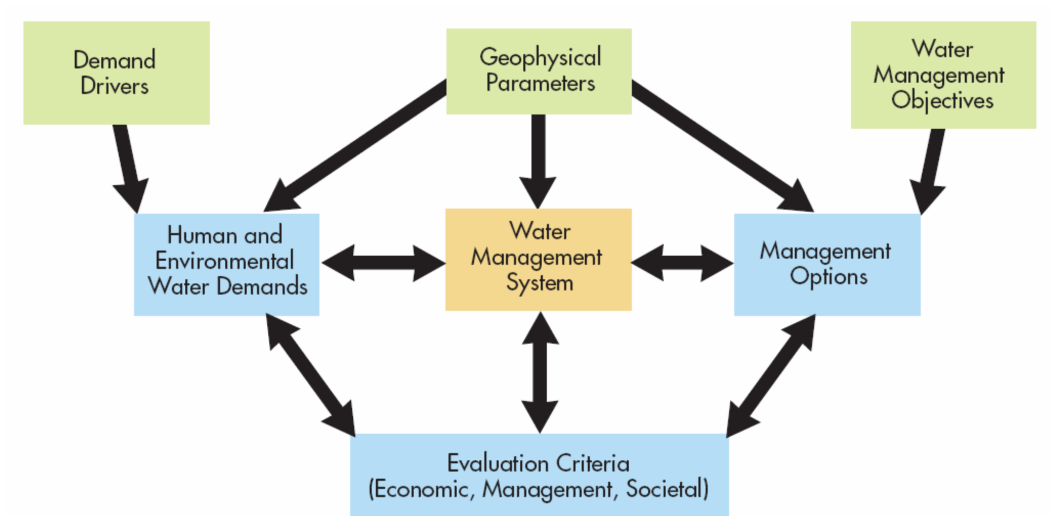


Figure 1: A Useful Integrated Scenario Analysis Framework from the CWP 2005 Update.

Having allowed for a range of scenarios at the top level, the framework moves to the second level, which is where the primary analysis occurs. At this level, the balance between different future levels of human and environmental water demand and different response packages (comprised of individual management options) can be assessed within the context of the California water management system. This is the place where computer models are used, as it is not possible to experiment directly on the actual systems of infrastructure, water rights and contracts, and regulations that define the California water system. This proposal offers the Water Evaluation and Planning system (WEAP) developed by the Stockholm Environment Institute (SEI) as an appropriate analytical framework, with a full discussion of the rationale for this recommendation given below.

For the moment, however, if one assumes that a suitable analytical platform is available, it should produce results that can, on the third level of the framework, be subject to evaluation with respect to a range of evaluation criteria defined by stakeholders and decision makers. While different stakeholders may place more or less importance on any one evaluation criterion, if the range of criteria is wide enough, each stakeholder should be able to assess whether a particular response package evaluated against a specific scenario represents an improvement for their particular constituency. It is at this third level that negotiation and decision-making occurs.

DWR also shifted the CWP 2005 Update towards a more regional, less centralized, planning approach. Whereas previous water plans aggregated data gathered at the local level, the primary goal was to estimate the statewide supply gap. Future water plans, on the other hand, will compliment the increasing investment on the part of the state on Integrated Regional Water Management Plans (IRWMPs). This planning process is designed to encourage water managers to identify water management response packages that help meet multiple objectives, including ensuring reliable supplies, at the local level prior to looking towards statewide water supply expansion. Obviously, for particular regions in California imported supplies from other regions will be critical to achieving reliability objectives, although such a strategy should not be assumed desirable *a priori*. As opposed to identifying the actions needed at the statewide level to balance all of California's potential supplies and demand, future CWP Update statewide integration will instead seek to assess the compatibility of regional plans with system-level opportunities and constraints after regional scenario analysis is complete.

In general, DWR's decision to pursue integrated scenario analysis through the implementation of this framework, and to focus first on regional assessment, has been welcomed in the California water community. As this transition to integrated scenario analysis represented a substantial departure from the supply gap analysis used in earlier Water Plan Updates, DWR was not fully able to implement the framework in Figure 1 as part of the CWP 2005 Update. That document focused largely on identifying important demand drivers and developing a small set of scenarios (three) with respect to human and environmental water demands. While a list of management options was elaborated, they were not linked to the demand scenarios through a model of the water management system. This proposal seeks to help DWR make substantial progress towards the full realization of the integrated scenario analysis framework in the CWP 2009 Update.

2. Context

This proposal is made within the context of substantial interactions between the proposing team and DWR on matters related to integrated scenarios analysis and the development of analytical tools. This section of the proposal traces some of the important aspects of these interactions over the past five years and our understanding of other interactions in which DWR has been engaged. It culminates in the recommendation that WEAP could be productively deployed as part of activity on the CWP 2009 Update.

CWP 2005 Update

The earliest thread in these interactions was the initiation of an informal collaboration between the RAND Corporation and DWR Water Planning staff as part of RAND's multi-year National Science Foundation study on decision-making under uncertainty. As a first step, RAND personnel worked with Water Plan Update staff members to develop a simple state-wide water demand model. Although not originally intended to inform the CWP 2005 Update, the model was selected by DWR to quantify three narrative demand scenarios that had been developed for the CWP 2005 Update (Groves et al. 2005). Although these scenarios of water demand were viewed as helpful by the Water Plan advisory committee, they were critiqued for treating supply scenarios and management responses as independent.

Southern California Scenario Analysis

After the release of the CWP 2005 Update, RAND and researchers from UC Santa Barbara continued to develop the scenario model to support analysis designed to identify robust water management strategies for California water planners (Wilkinson and Groves 2006). In this application, which was included by DWR as a case-study for its new Statewide Water Analysis Network (SWAN), the project team took a first step at integrating water demand and supply scenarios with management responses in a single annual water demand/water supply ledger. Although the underlying model was simplistic, and devoid of detailed physical elements, participants in several Southern California workshops in the fall of 2005 found the integration to be critical for extracting value from the demand scenarios. A major conclusion of the work, however, was that an improved physical representation of hydrology and the actual water management system would be useful, even for high-level scenario planning.

WEAP Application to the Sacramento Hydrologic Region

Independent of the interaction between DWR and RAND, the Stockholm Environment Institute (SEI) and the National Center for Atmospheric Research (NCAR) collaborated to develop an analytical framework for integrating climate change into water management planning. This project took the WEAP water resource systems modeling platform that SEI had been developing for over a decade as a point of departure. WEAP had long been a tool where integrated scenarios of water demand and water supply management could be simulated, typically using historical hydrologic observations as input. In this project SEI nested WEAP's water management logic within a rainfall runoff model of the terrestrial components of the hydrologic cycle, run using climatic input. This enhancement was critical, for the consideration of climate change as the assumption that historical hydrologic patterns will recur under future climate regimes is suspect. This enhanced tool was used to develop a WEAP application of the Sacramento Hydrologic Region that was the basis of several research papers (Purkey et al. 2007; Yates et al. 2005a; Yates et al. 2005b). The model was then included by DWR as a SWAN case-study, where verification of the model's simulated mass balances and the addition of a Delta salinity module were undertaken.

Inland Empire Utilities Agency Studies

Based on the utility of WEAP as a tool for climate change analysis, the RAND team adopted WEAP as a platform for its next analysis, which focused on Southern California's Inland Empire Utilities Agency (IEUA). In this study, the RAND team partnered with scientists from NCAR to develop state-of-the-art projections of future local weather patterns (out to 2040) reflective of a wide-range of plausible climate change outcomes as estimated by 21 climate models (Tebaldi et al. 2005; Yates et al. 2003). Subsequently RAND developed a WEAP application of the IEUA service area to generate integrated demand and supply scenarios reflective of various water management options. RAND used WEAP together with exploratory modeling software to evaluate the performance of a variety of water management strategies across hundreds of climate scenarios. RAND's scenario methodology suggested strategies that were robust to uncertainties about climate change and other management uncertainties. RAND presented results in three workshops in the fall of 2006 and one in the fall of 2007 (Groves et al. 2007; Groves et al. forthcoming). Several DWR staff members participated in these workshops as part of the SWAN case study process. A key finding from the work is that integrated scenario analysis was very effective at informing decisionmakers about climate change and other threats posed by uncertain future conditions and about choices among management strategies.

CalSim Development

One important thread of interaction between DWR and the project team has occurred outside of the actual Water Plan Update process where project partners MWH and SEI have been heavily involved in the development and enhancement of CalSim, the central water planning model used by DWR. While CalSim was not selected as an engine for scenario analysis in the CWP 2005 Update, largely because of its dense model structure and long run times, the model contains a very detailed representation State Water Project and Central Valley Project operations that could be mined to assemble a screening model to more appropriately represent the water management system at the heart of statewide water management in California. This has been the primary motivation for the development of CalSim-Lite, a simplified version of the model that may provide a platform for statewide integration of the regional analysis in the CWP Update. Owing to its familiarity with the California water system and CalSim, the project team will be in a good position to develop a detailed proposal on how statewide integration of the results from regional scenario analysis could occur.

Each of these efforts was successful in addressing different aspects of the integrated scenario analysis framework depicted in Figure 1. The CWP 2005 Update presented several demand scenarios and a list of management options, but did not integrate them. The follow-on 'Southern California Scenario Project' integrated scenarios of supply and demand, but did so without a detailed representation of the actual water system. The Sacramento Valley WEAP application developed a detailed and realistic systems representation of demand and supply under climate change, but did not explore a wide range of management options. Finally, the IEUA WEAP application reflected all elements of the system, but simplified the representation of hydrology and of the water system itself. Figure 2 summarizes the contrasting characteristics of each of these studies. The last row of the table in Figure 2 corresponds to the CWP 2009 Update, and the columns are currently populated by question marks.

The DWR and the Water Plan Update stakeholders are currently evaluating options for developing long-term quantitative analysis for future water plan updates. Most notably, DWR has engaged in a discussion with other potential partners pertaining to Shared Vision Planning as a promising procedural structure for CWP Update process. Shared Vision Planning is a facilitated collaborative process that engages a range of stakeholders in all levels of the integrated scenario analysis framework in Figure 1, starting from the definition of analytical assumptions and the crafting of scenario storylines, continuing through the selection, development and deployment of a modeling framework, and terminating with the evaluation of alternatives using a broadly subscribed set of performance metrics. Recent literature (Call 2001; Gregory and Failing 2002) suggests that Shared Vision Planning can be an effective strategy for creating consensus among a disparate group of stakeholders involved in water resources policy-setting and decision-making.

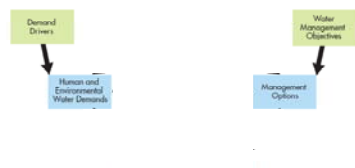
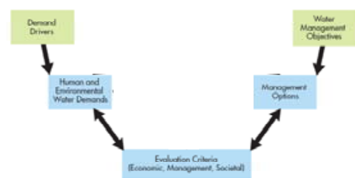
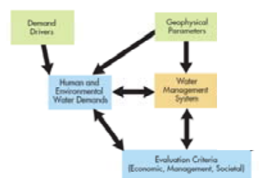
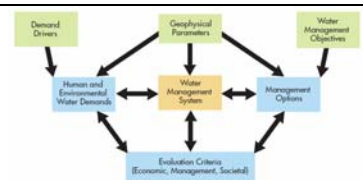
	Scenario Framework	Geographic domain	Level of integration	Level of System detail	Climate/hydrology
CWP 2005 Update		Statewide, by Hydrologic Region	No integration between demand scenarios and management options	Coarse demand factor representation. Management options derived from other studies	Annual data for past hydrology (water portfolios), no climate or hydrologic signal in scenarios
Simple Scenarios for Southern California		Southern California. Demand by county, supply by region	Arithmetic combination of supply and demand. Factor changes to baseline estimates	Coarse demand factor representation. Management options derived from other studies and related to supply and demand projections	Annual projections of supply and demand. No interannual variability. No climate signal.
Sacramento WEAP application		Sacramento Basin, including Bay-Delta and Trinity Diversion	Full integration with demand and supply elements interacting dynamically during simulation	Full system detail with all critical system components represented explicitly	Monthly precipitation, temperature, RH and wind. Rainfall/snowmelt simulation->runoff. Water quality simulation.
Robust management strategies for IEUA		Inland Empire Utilities Agency service area.	Integrated supply and demand and long-term water management plans	Aggregated representation of large system components.	Monthly precipitation, temperature, RH and wind. Rainfall/snowmelt simulation->runoff. Parameterizations of effects on imports.
CWP 2009 Update	???	???	???	???	???

Figure 2: Evaluation of Previous Scenario Analysis Efforts with Respect to the Integrated Scenario Analysis Framework

This is an attractive prospect, given DWR's experience in moving towards an integrated scenario analysis framework in the CWP 2005 Update. That transition was complicated because the analytical framework that DWR proposed to represent the California water management systems, a loosely integrated collection of models developed by DWR for other purposes, was not universally endorsed by the stakeholders involved in the CWP Update process. The lack of consensus on this central element of integrated scenario analysis prevented those working on the update from implementing the framework shown in Figure 1 in its entirety. There is legitimate enthusiasm that if the entire integrated scenario analysis framework could be placed within a Shared Visioning Planning process, then a consensus would emerge around input assumptions, models, and performance metrics increasing the creditability, and hence the utility, of the CWP Update.

This expectation shapes DWR's current conversation around Shared Vision Planning which is pointing towards the collaborative definition of an appropriate integrated scenario analysis framework for the coming CWP 2009 Update, with the full implementation of that framework being realized only in the 2014 Update. As part of the development of this framework, one activity that will be undertaken for the CWP 2009 Update is an inventory of all planning work that is currently underway at regional and system-wide levels, with an eye towards identifying promising methodologies and highlighting key planning challenges and management opportunities.

There is also, however, the expectation from both the stakeholder community and DWR management that in addition to thinking about a long-term strategy for integrated scenario analysis, the Water Plan staff should also try and make substantive progress in developing analytic scenario results for 2009 Update. This proposal offers an option for conducting near-term analysis for the 2009 Update that builds upon the other studies in Figure 2 and will provide relevant findings and lessons learned for future water plans. This proposal adopts the point of view that demonstrating integrated scenario analysis for several planning units within California in the CWP 2009 Update could provide a very useful Shared Vision laboratory for defining the elements of any ultimate integrated scenario analysis process.

Indeed it is not easy to imagine how the Shared Vision Planning process would guide stakeholders through these steps entirely in the abstract, absent any model on which the concepts of scenarios and performance metrics could be explored. Accepting then the utility of a modeling framework as self-evident, this proposal argues that a useful and appropriate representation of the California water system can be developed in WEAP in a timely manner by leveraging all of the work that has already been produced as part of the CWP 2005 Update and SWAN collaborations between DWR and the proposed project team.

3. Approach

DWR has already begun developing in WEAP a high-level regional demand and supply balance representation of the ten Hydrologic Regions in California. Our proposed project would complete and then build upon this work and the other SWAN case studies and employ the WEAP modeling tool to simulate and evaluate more refined integrated water management scenarios for two of the ten California Hydrologic Regions for the CWP 2009 Update. The project would focus on one of the major water source regions—the Sacramento River hydrologic region—and one major demand region—the South Coast. This framework would both quantify a small set of hand-crafted narrative scenarios developed by the CWP Update staff and advisory committee and generate a larger ensemble of plausible scenarios to systematically evaluate the performance of various regional water management response packages in the face of a number of critical uncertainties, including climate change and others. Work would be undertaken in pursuit of the following specific objectives:

1. Develop a modeling framework that can demonstrate the entire integrated scenario analysis framework envisioned in Figure 1 for two key regions in California—Sacramento River and the South Coast--envisioned in Figure 1 as part of the CWP 2009 Update.

2. Use this framework assess the full spectrum of uncertainties that confront water planning in California, including global climate change, land use and demographic changes, and others.

3. Evaluate the results of these analyses against an appropriate set of performance metrics, introducing the notions of robustness and risk as part of the evaluation process.

4. Develop a strategy to evaluate the most promising regional water management strategies using some version of CalSim so that insights gained through integrated scenario analysis at the regional level can also be simulated in DWR's principal planning model for the California water system.

5. Offer insights to a parallel Shared Vision Planning process that will advance a more definitive strategy for integrated scenario analysis for use in the CWP 2014 Update, and beyond.

Achievement of these objectives will contribute substantially to the continued evolution of the CWP Update leading to a comprehensive integrated scenario analysis approach.

To organize the scenario analysis that this project would support in advance of the CWP 2009 Update, Figure 3 presents a preliminary summary of key uncertainties around exogenous factors (X), response packages levers that can be manipulated by water managers (L), performance metrics (M), and interrelationships (R) that would be evaluated in a WEAP based representation of portions of the California water system. This XLRM framework has been found to be a useful way of organizing the major elements of a quantitative scenario-based decision analysis (see Chapter 4, Lempert et al. (2003)). This table attempts to call out what are likely to be key themes of CWP 2009 Update: climate change; efforts to reduce stress on the Sacramento-San Joaquin Delta; managing uncertainty and risk; sustainability; and flood management.

Uncertainties/Planning Assumptions (X) • Temperature trends • Precipitation trends • Population growth • Naturally occurring conservation • Land use policy • Land cover change • Delta pumping rules and restrictions	**Response Packages (L)** • Current management • Currently planned regional development • New surface storage • New conveyance • Accelerated conjunctive use • Accelerated wastewater reuse • Accelerated water use efficiency • Innovative water transfer markets • Increased storm water capture • Adjusted Flood reservation rules
WEAP Model Relationships (R) • Soil-moisture model connected to groundwater nodes • Indoor demand based on households and sector specific drivers • Outdoor demand based on monthly temperature and precipitation • SWP and CVP Operations Delta model	**Performance Measures (M)** • Annual demand by region • Annual available supply by region • Water supply reliability by demand region • Average difference between demands and available supply • Patterns of critical environmental flows • Frequency/magnitude of spills

Figure 3: Preliminary scope of proposed scenario analysis using the XLRM framework.

4. Work Plan

In order to implement the proposed approach for integrated scenario analysis, several tasks needed to be completed. Task 1 is underway and will be completed by the CWP 2009 Update staff and consultants. The remaining tasks will be completed as part of a new project that would be launched early in 2008. Details for Task 0: Project Management are not included in this work plan narrative, although they are accounted for in the proposed project budget in Section 6.

Task 0: Project Management and Coordination

This task will cover activities related to the overall management of the technical activities described in the following tasks, and there coordination with other planning processes, such as the storage investigations and the climate change team, within DWR.

Task 1: Define a list of key exogenous factors, qualitative ranges, and scenario themes

This first task will begin with an Advisory Committee workshop to be held in late November. Information on scenario elements, to be developed by DWR staff, will provide the foundation for scenario analysis that will be included in the proposed project. The starting assumption is that the key exogenous scenario factors which are outside of the control of water managers, their potential ranges, and overarching themes will be available for use in a timely fashion when the proposed project kicks off early in 2008. As one of the project partners, the RAND Corporation, will support the effort to define these key scenario elements, it is reasonable to assume that the provision of this foundation will be appropriately coordinated with the proposed project. While it is critical to the success of the proposed project, Task 1 is covered by a separate contract and is not included in the propose project budget in Section 6.

Task 2: Develop high-level model of annually-averaged demand and supply for each Hydrologic Region using WEAP

This task represents the most direct continuation of the activities undertaken as part of the CWP 2005 Update and subsequent activity within DWR. For the past few years, Dr. Mohammad Rayej of the Division of Planning and Local Assistance at DWR has been working extensively with WEAP. One major focus of his activity has been to re-implement in WEAP the logic used to quantify the CWP 2005 Update demand scenarios that were originally programmed in Analytica®. This has been successfully done for each of the ten Hydrologic Regions in California. In addition, Dr. Rayej has begun to experiment with representing different annual average supply availability scenarios or response packages, in WEAP, using an inventory methodology similar to that of Wilkinson and Groves (2006) for the South Coast as part of an earlier SWAN case study. This has also proved feasible. This task will cover continued analytical and methodological support to DWR, through refinement and improvement of this high level regional analysis for each of the 10 hydrologic regions.

This refinement of the 2005 Update effort will likely be required; since at the conclusion of Task 1, it may turn out that that an alternative set of scenario logic should be employed in 2009. Nonetheless, the successful porting of the 2005 logic to WEAP demonstrates that the platform is suited for this sort of analysis. It is important to note that these balances will not fully reflect constraints and opportunities associated with actual regional water management systems. Refining the representation of these regional details will be the focus of later tasks. In terms of the proposed team, the primary role on this task will be to provide technical support and advice to DWR staff working on this analysis.

The output of this task will be a series of high level, annual water supply and demand account balances under the range of scenarios developed in Task 1. In addition, some minor additions to the WEAP user interface will assist in facilitating the representation of the range of scenarios in a highly user friendly manner, allowing stakeholders the ability directly evaluate their alternatives and associated outcomes (see Task 3). The goal will be to take full advantage of the visual, object-oriented, modeling structure available in WEAP.

Task 3: Enhance WEAP software

This task would advance the WEAP software to support the proposed integrated scenario analysis. This would involve enhancements to facilitate the implementation of scenario based model logic and to facilitate scenario experimentation by stakeholders. Specifically, SEI would modify the definition of new variables in the *Key Assumptions* so that they could be defined as arrays for which a series of values can be read in from external databases or modified through a series of "scenario wizards". The expression building functionality of WEAP will also be expanded to allow operation on these arrays through a range of index based computations. Further, SEI will develop an easy-to-use scenario interface development wizard that will allow the user to bring critical scenario inputs and outputs onto a control panel so that in running a scenario the user could avoid making specific changes to the underlying model database and sorting through the voluminous output associated with a particular WEAP run. As part of the proposed project, SEI would make the modified version of WEAP available for use, free of charge, by all stakeholders in the CPW Update process.

Task 4: Develop a hydrologically-based supply and demand representation of the Sacramento Hydrologic Region in WEAP

As part of previous work in the Sacramento River Hydrologic Region, a highly refined WEAP application has been developed which captures much of the system detail in this part of California. Starting from historical climate input, the application simulates both surface and groundwater supplies, water demands, and system operations in a manner which approximates the actual behavior of the system in the last two decades of the 20th Century. In developing this application, the goal was to develop a tool that could be used to investigate how critical elements of the water system in the Sacramento River Hydrologic Region would respond to potential changes in climate. In this effort, little attention was paid to assembling the model along the lines of the DWR Planning Areas in the Sacramento River Hydrologic Region, which are likely to emerge as the most fundamental local analysis unit in the CWP Update process.

In theory, each DWR Planning Area can be considered a control volume on which a mass balance can be performed, and, in fact, the well received portfolio analysis of historic mass balances are implemented at the scale of Planning Areas. As such, it ought to be possible to represent each Planning Area as a discrete model into which and from which exchanges with neighboring Planning Areas can be represented. This is the assumption that will be tested in this task in order to see how well representations developed at the scale of Planning Areas can be aggregated up to represent the water system at the scale of the Hydrologic Region. Likewise, the current WEAP model of the Sacramento River Hydrologic Region has representations that are finer than that of an individual Planning Area. Therefore, we will also test what spatial scales within a planning area are needed to capture important hydrologic variations relevant for that and other planning areas. For example, one of the eleven planning areas of the Sacramento River Hydrologic Region is the entire high elevation Sierra Mountain region (PA 508) and is configured in the current WEAP applications as roughly 50 sub-catchments. The critical question is how many sub-catchments are necessary to capture important hydrologic variations relevant to the other Planning Areas?

We will investigate how the simulated results for the Sacramento River Hydrologic Region change if the model is reorganized according to the eleven Planning Areas that DWR has defined for the Sacramento River and at different levels of spatial representation within a Planning Area. The modeling experiment conducted as part of this task will provide critical insight into the challenge of building an analytical platform at the Planning Area level that can be assembled to provide reasonable representations of system constraints and opportunities at the Hydrologic Region and statewide levels. Once this experiment has been completed, the new model will be used to assess the performance of various management strategies, or response packages, proposed for the Sacramento River Hydrologic Region under a range of uncertainties related to climate change and other drivers.

Task 5: Develop a hydrologically-based, programmatic representation of supply and demand for the four Planning Areas scale in the South Coast Hydrologic Region

The representation of demand and local supply in the South Coast region will be developed by expanding RAND's application for IEUA to the four planning areas, keeping roughly the same level of detail. This model will project scenarios of urban demand that consider alternative population growth rates, housing patterns, landscape patterns, water use intensity (as a function of water price, household income, and naturally occurring conservation), and monthly temperature and precipitation (for outdoor demand). Agricultural demand projections will be based on estimated land use trends and agricultural water use intensity.

We will projection monthly supply availability using several different methodologies. For local surface supplies, we will establish relationships between weather (temperature and precipitation) and yields based on historical data. These relationships will then be used to project future local surface supplies. Groundwater recharge rates will be related directly to the future sequences of monthly weather, via the WEAP soil-moisture algorithm. Groundwater replenishment via conjunctive use programs will be explicitly represented. The mass balance of the major groundwater basins would then be calculated, reflecting changes in natural replenishment, artificial recharge, and pumping. Projections of recycled and desalinated supply will be based upon capital improvement plans for the regions. Availability of imports via the State Water Project, Colorado River, and Owens Valley will be treated as assumed model inputs whichreflect plausible responses to climate variability and changes in their source regions, so as to avoid having to develop full climate driven models for these regions.

The model will explicitly reflect a variety of local response packages including the development of regional recycled water programs, increased urban water use efficiency, and more extensive conjunctive use. Exogenous changes in baseline imports will also be included.

Task 6: Develop future sequences of weather consistent with a wide range of climate change projections (and historically conditions for comparison)

In order to conduct scenario analysis related to future climate change, the analysis will rely on an 1/8th degree gridded historical climate dataset (1950 through 2000) developed by Maurer (2002) to create a unique monthly climate dataset (precipitation, temperature, humidity and wind) for each sub-catchment of the two detailed WEAP applications developed in Tasks 4 and 5. Climate change scenarios developed by the California Climate Change Center (CCCC) (Cayan et al. 2006) will then be configured for use in the updated WEAP applications.

Task 7: Evaluate water management response packages for different scenarios

In this task, we will exercise the WEAP applications developed in tasks 4 and 5 to evaluate how various response packages will perform under different scenarios. These scenarios will reflect plausible changes in climate as reflected in the data obtained and adapted in Task 6; demand drivers such as population, naturally occurring conservation, and development patterns; and others as developed in Task 1. This will occur by first evaluating a set of response packages for the small set of hand-crafted narrative scenarios developed by the Advisory Committee. The results from this limited set of runs can then be displayed using standard scenario planning tables and graphics. The results from this limited set of runs can then be displayed using standard scenario planning tables and graphics. Next a much larger set of scenarios will be evaluated following a systematic experimental design to span the space of plausible conditions. Robust decision making methods will be used to characterize the conditions in which each response package performs well and poorly. This information can then be used to define a smaller set of policy-relevant scenarios that can be described in greater detail and highlighted in the CWP Update 2009 (Groves et al. 2007; Groves and Lempert 2007).

Task 8: Develop a plan to link regional analysis output to systemwide analytical tools such as CalSim or CalSim-Lite.

CalSim and CalSim-Lite, system-wide models that simulate the operation of the State Water Project and the Central Valley Project, are accounting tools that make storage release and delivery decisions on a monthly time-step. All water supplies and water demands are pre-processed and used as model input. These models do not simulate climate-driven hydrology, or climate-driven demands, nor do they have embedded agricultural and urban demand modules. Under this task, a strategy for mapping WEAP-based water supply and water demand scenarios into CalSim and/or CalSim-Lite inputs would be developed. Recommendations would be offered for how climate-driven demands and management responses would be pre-processed and simulated in these system-wide models. Based on this strategy a limited set of scenarios would be modeled in order to demonstrate system-wide effects, and the integration of local/regional scale planning efforts at a larger state-wide scale.

Task 9: Training for interested stakeholders on the use of WEAP

A key component of this proposal would be to hold two training sessions on WEAP and its use as part of a robust decision making process in order to enable stakeholders to work with the research teams in the development of the proposed analytical tools. One workshop will be held in Southern California, the other in the Sacramento region.

Task 10: Reporting

At the conclusion of the project, the project team will work with DWR staff to prepare a technical appendix on all work completed on the proposed project. It the request of DWR, the project team may also be involved in the preparation of text and graphics for the main body of the document at well. As the extent of involvement in the development of the actual CWP Update document is unclear, the proposed budget included covers the requirements for the technical appendix alone.

5. Tentative Schedule

As mentioned above, the primary motivation for this proposal is to produce quantitative analysis of a range of water management scenarios within a time frame that permits the insights gained from the effort to be included in the CWP 2009 Update. This will be accomplished by adhering to the following implementation schedule, which assumes that formal activity will begin at the start of 2008. As mentioned above, while Task 1 is critical to the ultimate success of the proposed project, it is being covered under a separate contractual agreement. While it is anticipated that this task will be completed early in the implementation of the proposed project, it has not been explicitly programmed in the tentative schedule.

	2008												2009					
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J
Task 0: Project Management	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Task 1: Scenario Elements																		
Task 2: Regional Analysis	■	■	■	■	■	■												
Task 3: Enhance WEAP	■	■	■	■	■	■												
Task 4: Sacramento River Analysis	■	■	■	■	■	■	■	■	■									
Task 5: South Coast Analysis	■	■	■	■	■	■	■	■	■									
Task 6: Climate Scenarios										■								
Task 7: Evaluate Scenarios											■	■						
Task 8: Statewide Integration											■	■	■	■				
Task 9: Training			■															
Task 10: Documentation													■	■	■	■	■	■

6. Proposed Budget

The proposed budget has been provided to appropriate contacts at DWR for consideration and discussion.

7. Conclusions

This proposal is offered with a substantial amount of excitement on the part of the project team. Our collective interactions with DWR over the past five years leave us convinced that we can produce output that will provide substantial progress on the path towards the integrated scenario analysis framework that will be the foundation of future editions of the CWP Update. Through our work on the 2005 edition and on the SWAN case studies, we are confident that we understand the challenges facing this transition and that we possess insights, experience, and tools that will assist DWR in meeting these challenges. We also understand there is not ample time to develop the definitive approach to integrated scenario planning in advance of the publication date for the CWP 2009 Update. For this reason, we welcome the initiative to implement Shared Vision Planning in pursuit this definitive approach, and would commit to having the current effort support the longer term initiative. Indeed, from our perspective, it seems that a decision by DWR to implement the steps outlined in this proposal would provide valuable input to the longer term objectives. We stand ready, in the event that DWR shares this perspective, to formalize a collaborative arrangement as quickly as possible and to begin work according to the proposed implementation schedule.

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